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LUNA-16 SOIL SAMPLES

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ACADEMICIAN A.P. VINOGRADOV DISCUSSES LUNA-16 SOIL SAMPLES

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During a press conference reviewing the successes of the Luna-16 mission, A.P. Vinogradov, geochemist and vice-President of the Academy of Sciences of the U.S.S.R., discussed the results of the analysis of the lunar soil samples returned by the Soviet probe.

The academician explained that the Luna-16 drill had penetrated relatively easily into the Moon's loose soil cover - the regolith - meeting resistance only at a depth of about 345 mm, when it came up against either bedrock or a large rock fragment. The drill was able to penetrate only 5 mm further (to a total depth of 350 mm) as was later confirmed by an examination of the core-sample.

The drill was completely filled by the sample of loose lunar regolith. When it was removed to an examination tray it did not have a layered appearance and appeared uniform through its length. Only a small part of the soil at the drill-face, at a depth of approximately 35 cm., consisted of more coarsely-grained material. The overall weight of the Luna-16 soil sample was a little more than 100 g (i.e., less than 4 oz.)

The regolith on the whole consists of variable-size grains of dark gray (blackish) powder, which shapes easily and sticks together in separate loose clumps. This peculiarity substantially differentiates it from the formless dust of Earth, in spite of the prevalence in it of fine-grained particles with an average grain measurement of about 0.08 - 0.1 mm. Because of this quality the lunar soil reminds one of damp sand or the lumpy structure of our soils.

Every type of impression remains clearly imprinted on the lunar soil, and semi-circular (drill) impressions were preserved along the core length. The soil even holds to vertical walls easily. Thus, a small pile 2 cm high poured through a funnel against a vertical glass wall held to it without flowing away, retaining the imprint of the latter and forming a 45 degree angle with it. In spite of its highly adhesive nature, the soil sifts easily through a sieve. Also of some interest is the high capacity of the lunar soil for retaining electrical charges.

The granularity of the soil increases with depth. Using this index and on the basis of granulometric analysis one can divide the sample into a series of zones, one gradually replacing the other, which we shall designate A,B,C,D,E,and F.

Zones A and B consist of fine-grained material with a small content of coarse particles and constituting the first 15 cm of the core. Zones C and D consist of material of variable-size grains including rock fragments and other particles measuring more than 3 mm in size and comprising the section of the core from 15 to 33 cm. Zone E is made up of coarse-grained material and constitutes the remaining length of the core (33 to 35 cm). Below this hard rock or rock fragments were found (Zone F).

The surface and loosest layer is included in Zone A (0-5 cm). Its characteristics are consistent with the basic optical properties of the lunar surface, which is related to the high porosity of the surface structure. Obviously, the deneseness of this loose cover varies from place to place, and the average volumetric weight at a depth of 5 cm, according to data from Luna-13, is 0.8 g/cc, which may also be assumed for the area in which Luna-16 landed.

The average particle size of less than 1 mm changes along the length of the core from 70 microns at the surface to 120 microns at its bottom.

The average volumetric weight of the soil as calculated along the depth of insertion of the drill was 1.2 g/cc. Upon being poured freely into a graduated cylinder and shaken down this increased to 1.8 g/cc. Therefore, the average porosity of lunar soil at a depth of 35 cm has been established to be 50-60 per cent.

Academician Vinogradov observed that the color of the lunar soil repeatedly evoked contradictory responses in observers, who sometimes saw it as greenish and at other times brownish. This might be explained by the fact that the lunar soil has been discovered to have unusual reflective and light scattering properties, so that at a close and normal viewing angle it has a greenish hue. An increase of viewing angle results in the appearance of a reddish-brown shade. The difference in the color perception also increases with an increase of the light falling on the surface of the soil.

Microscopic examination of the particles reveals all kinds of variety, some of which depart radically from earthly phenomena. The particles may be divided into two main classes, i.e., those of original magmatic rock (basalt), and those which had been exposed to significant transformation on the lunar surface. Characteristic of the first type is its remarkably fresh appearance, observed on Earth only in freshly-crushed samples of original rock. They show practically no signs of "wear".

On the other hand, Vinogradov observed, one also finds a large number of sintered particles of complex and odd shapes, often with glazed surfaces, as well as a significant quantity of spherical fused formations - solidified droplets - with a glassy or metallic appearance, similar to the tektites encountered on Earth.

The academician then proceeded to classify the types of lunar rock. The basalts encountered consisted of two varieties characterizing the conditions of solidification of the molten basalt, i.e., fine-grained and macrocrystalline basalt of the gabbroid type. These constitute about one-quarter of all coarse-grained particles. The basic components of these rocks are plagioclase, pyroxene, ilmenite and olivine, the relative concentration of which varies from particle to particle.

Next in evidence were feldspar rocks (anorthosites), which are white polycrystalline grains found in insignificant quantity. They are interesting in that they are considered examples of bedrock which have been scattered over great distances.

Among the particles consisting of single crystals are those mentioned above as the basic components of basalt, i.e., plagioclase, olivine, pyroxene and ilmenite. These were not numerous among the large grains, but appeared more frequently as the size of the particles decreased.

Glassy spherules and other glazed formations were found in the sample. These included pear-shaped and dumbbell-shaped hardened droplets of various color, transparent, cloudy-white, greenish, yellow-brown, and some opaque, even hollow. Their luster varies from glossy to metallic. Their quantity increases among the fine grains. They are formed by impacting meteorites at temperatures substantially exceeding that of molten rock, and then harden after being splattered in molten form.

Also encountered were breccias and sintered conglomerates, evidence that even while the crushing and pulverization of the regolith continues there is in process a consolidation of the particles into aggregates. Some half of the latter include some form of glazing in which dark-brown to black shades of glass predominate. This typically lunar fusion can result only during the instantaneous heating of completely cold particles, which differentiates this type of glazing sharply from that resulting from volcanic activity.

Some particles of metallic iron were found, apparently from iron meteorites, but this was rare. Small inclusions of iron were also found in some breccias and sinters.

In conclusion, Academician Vinogradov presented a chart comparing the chemical composition of lunar rock based on an analysis of the samples returned by the Luna-16 with those returned by the Apollo program.

CHEMICAL COMPOSITION OF LUNAR ROCK

	Basaltic Rock Luna-16	Fine Particles Luna-16	Basaltic Rock Apollo-12	Fine Particles Apollo-12
SiO_2	43.8	41.7	40	42
TiO_2	4.9	3.39	3.7	3.1
Al_2O_3	13.65	15.32	11.2	14
FeO	19.35	16.8	21.3	17
MgO	7.05	8.73	11.7	12
CaO	10.4	12.2	10.7	10
Na_2O	0.33	0.37	0.45	0.40
K_2O	0.15	0.10	0.065	0.18
MnO	0.2	0.21	0.26	0.25
Cr_2O_3	0.28	0.31	0.55	0.41
ZrO_2	0.04	0.015	0.023	0.09

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